

# Moisture and mould problems a threat against sustainable buildings

## The BETSI study in Sweden



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### Summary

The Swedish National Board of Housing, Building and Planning has produced an updated description of the Swedish building stock, with input from surveys and questionnaires. Particular focus has been on collecting data concerning damage on buildings, lack of maintenance and data for development of environmental quality objective a Good Built Environment. Approximately 1800 surveys were carried out in statistically selected buildings. One part of the investigation was to find the extent of moisture damages and mould growth that may affect the indoor environment.

The results show that approximately 1/3 of the Swedish buildings have a moisture damage with mould growth or bad odor with a possibility to affect the indoor environment. Moisture and mould are much more common in single houses, and a comparison with a similar investigation 17 years ago shows that moisture damages have increased.

Many moisture and mould damages are in ground constructions that are well known for their moisture problems, as elder slab on the ground, crawl spaces and cellars with additional insulation on the inside. Mould in attics is very common both in old and new buildings, as well as moisture damages in new wooden framed walls with external thermal insulation with rendering.

**Keywords:** Building, moisture, damp, mould, damage, description, survey, indoor, environment, BETSI.

### 1. Introduction

The Swedish National Board of Housing, Building and Planning has produced an updated description of the Swedish building stock, with input from surveys and questionnaires, called the BETSI study. Particular the focus has been on collecting data concerning damage on buildings, lack of maintenance and data for development of environmental quality objective a Good Built Environment. From the results of the BETSI study the goal was set to reduce the moisture damages by half to the year 2020. Approximately 1800 surveys were carried out in statistically selected buildings. One part of the investigation was to find the extent of moisture damages and mould growth that may affect the indoor environment.

The method used in the BETSI study is based on ocular investigations, measurements and inquiries to families living in houses and apartments. One purpose with the investigation was to map out the extent of the moisture and mould damages in the Swedish building stock from the aspect of inconvenience in the indoor environment. In Sweden it is common that the buildings are built with a heat insulated wooden frame construction. Usually the moisture and mould attacks are hidden inside the construction or in crawl spaces and in attics. Since it is not possible to observe these hidden damages with an ocular investigation a protocol was prepared with questions about construction details, damages and bad smell in the building. When locating and sorting out moisture damages a special definition was made for the BETSI study. A moisture damage in the study means that moisture and mould may have an impact on the indoor environment.

Following checkpoints were used for the definition:

- There was observed ocular visible mould growth and smell of mould or other bad smell from moisture damages. In most of the crawl spaces, attics and indoor surfaces the moisture damages were possible to inspect.
- There was observed a bad smell of mould but no visible damages. Then the smell was assumed to be caused by a moisture damage. The description of the construction and drawings were used to detect any well known critical construction in the building that could be assumed to be the source of the moisture damage. In some cases moisture measurements were taken inside outer walls for indications of moisture damages.

The method was made for overlooking a very large number of houses for a statistical purpose. Normally an investigation for solving an indoor health problem in a building has to be more precise.

## **2. Results**

The results show that approximately 1/3 of the Swedish buildings have a moisture damage with mould growth or bad odor with a possibility to affect the indoor environment. In older single family houses moisture damages are found in about 45 percent of them, and in about ten percent of the newer houses. In apartment houses moisture damages are found in about 17 percent of the elder buildings and in approximately 3 percent of the newer buildings.

## **3. Discussion**

The results of the BETSI study shows that many of the moisture damages depends on bad construction design both on older and new buildings. There are many houses from the 1970s and older with moisture damages that have to be taking care of. Although we have knowledge about earlier mistakes in the construction design it seems that new products sometimes can be insufficient in design and testing.

The attic and the crawl space foundation are constructions where mould growth seems to have increased during the last decades in older single family houses, but also in attics in new houses. The investigation have not given the answer why, but some hypothesis are the relatively warm winter climate during the 1990s up to 2006. For attics there also have been a development of the construction with increased heat insulation in new houses and additional heath insulation in existing houses. The knowledge about mould and moisture problems have increased during the last decades and the surveyors perhaps have more attention to mouldgrowth and bad odor nowadays.

The conclusion is that moisture damages can be a threat against sustainable buildings due to many older bad constructions still remains and new untested constructions are built, with the risk that some of them gradually can lead to moisture damages and health problems In today's houses.

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The results show that approximately 1/3 of the Swedish buildings have a moisture damage with mould growth or bad odor with a possibility to affect the indoor environment. Moisture and mould are much more common in single houses, and a comparison with a similar investigation 17 years ago shows that moisture damages have increased.

Many moisture and mould damages are in ground constructions that are well known for their moisture problems, as elder slab on the ground, crawl spaces and cellars with additional insulation on the inside. Mould in attics is very common both in old and new buildings, as well as moisture damages in new wooden framed walls with external thermal insulation with rendering.

This paper will include description of the used method from joint preparation of experts to analysis of results. Samples of results as basis for discussion on the status of the buildings and the methods used, and conclusions on how to use the extensive data that is now available.

**Keywords:** Building, moisture, damp, mould, damage, description, survey, indoor, environment, BETSI.

## 4. Introduction

### 4.1 Background

The Swedish National Board of Housing, Building and Planning has produced an updated description of the Swedish building stock, with input from surveys and questionnaires, called the BETSI study. Particular the focus has been on collecting data concerning damage on buildings, lack of maintenance and data for development of environmental quality objective a Good Built Environment. From the results of the BETSI study the goal was set to reduce the moisture damages by

half to the year 2020. Approximately 1800 surveys were carried out in statistically selected buildings. One part of the investigation was to find the extent of moisture damages and mould growth that may affect the indoor environment. [1]

This paper shows the status and the change of moisture and mould damages in the Swedish building stock, during time and from that point of view the discussion is carried out. Results from schools and nurseries are not included in this paper. [2]

## **4.2 Health problems**

The WHO (World Health Organization) has stated in their brochure according to their guidelines about moisture and mould that “excessive dampness and mould are a threat to health. Occupants of damp and moldy buildings are at increased risk of experiencing health problems such as respiratory symptoms, respiratory infections, allergic rhinitis and asthma. [3]

## **4.3 The method**

The method used in the BETSI study is based on ocular investigations, measurements and inquiries to families living in houses and apartments. The investigation method is described in the Sustainable building 2011 paper “Method to describe the technical characteristics of the existing buildings - A Swedish survey of 1800 buildings”. [4]

One purpose with the investigation was to map out the extent of the moisture and mould damages in the Swedish building stock from the aspect of inconvenience in the indoor environment. In Sweden it is common that the buildings are built with a heat insulated wooden frame construction. Usually the moisture and mould attacks are hidden inside the construction or in crawl spaces and in attics. Since it is not possible to observe these hidden damages with an ocular investigation a protocol was prepared with questions about construction details, damages and bad smell in the building. When locating and sorting out moisture damages a special definition was made for the BETSI study. A moisture damage in the study means that moisture and mould may have an impact on the indoor environment. Moisture damages with no meaning to the indoor environment are not included in this study.

Following checkpoints were used for the definition:

- There was observed ocular visible mould growth and smell of mould or other bad smell from moisture damages. In most of the crawl spaces, attics and indoor surfaces the moisture damages were possible to inspect.
- There was observed a bad smell of mould but no visible damages. Then the smell was assumed to be caused by a moisture damage. The description of the construction and drawings were used to detect any well known critical construction in the building that could be assumed to be the source of the moisture damage. In some cases moisture measurements were taken inside outer walls for indications of moisture damages.

The method was made for overlooking a very large number of houses for a statistical purpose. Normally an investigation for solving an indoor health problem in a building has to be more precise.

## **4.4 Earlier investigations**

In the year of 1991 a quite similar investigation called the ELIB study was made on the building stock built up to 1989. There was also made ocular investigations of moisture damages in about 1100 single- and multifamily houses that were statistical selected. The results from the ELIB study have been useful in comparing the change of moisture damages over time. [5]

## 5. Results

### 5.1 Moisture damages in buildings

The number of buildings with at least one moisture damage that may have an impact on the indoor environment is displayed in Table 1.

*Table 1: Buildings with at least one moisture damage with the possibility to affect the indoor environment. The share of the buildings is representative for the total amount of buildings in the same group.*

Type of building	Category of year	Number (1000'th)		Share (%)	
Single family houses	-60	381	± 134	45	± 16
	61-75	213	± 72	43	± 14
	76-85	84	± 34	27	± 11
	86-95	33	± 15	21	± 10
	96-05	7	± 4	10	± 5
All single family houses		718	± 157	38	± 8
Apartment buildings	-60	13	± 7	17	± 9
	61-75	5	± 3	15	± 9
	76-85	2	± 1	16	± 11
	86-95			3	± 3
	96-05			(3)	
All apartment buildings		22	± 9	13	± 5
Commercial buildings		11	± 4	23	± 9
All buildings		751	± 159	36	± 7

( ) Uncertain value.  
1) Share of building parts with a damage in the same category

It is common with moisture damages in Swedish buildings, as displayed in Table 1. The result gives no information about how serious the damages are or if they really affect the indoor environment. The most damages are found in single family houses and about 1/3 of all buildings have moisture damages with the possibility to affect the indoor environment.

The investigated building parts parts are the foundation, outer wall, roofs and attics, and also the bathrooms are included as a part of the building.

In Table 2 it is displayed in which building parts the moisture damages are most frequent in the Swedish building stock.

Table 2: Building parts with at least one moisture damage with the possibility to affect the indoor environment.

Type of building part	Category of year	Number of buildings (1000 th)		Share <sup>1)</sup> (%)
Attics	-75	387	± 123	26 ± 8
	76-05	62	± 28	10 ± 5
	Total	449	± 127	21 ± 6
Foundations	-75	334	± 79	22 ± 5
	76-05	62	± 26	10 ± 4
	Total	396	± 80	19 ± 4
Outer walls		60	± 32	3 ± 2
Bathrooms	damages	**		2 ± 2
	risk of damages			16 ± 5
All buildings		953	± 160	

\*\* Uncertain value.

1) Share of building parts with a damage in the same category.

The results in Table 2 displays that moisture damages are very common in attics and foundations. Recently there have been a lot of moisture damages in outer walls which are built with a wooden framed construction combined with an unventilated facade plaster system, called the ETIC facade system. Although these damages are quite serious, the number of buildings with this type of damage are few compared to the whole building stock.

Observed moisture damages from bathrooms are few, but the bathrooms in need of renovation in order to avoid moisture damages are about 16 percent of all bathrooms.

## 5.2 Well known problem constructions

In Table 2 it is displayed that the moisture problems in ground constructions are common in the old categorie of buildings. Between the end of 1950s to the end of 1970s a large number of single- and multifamily houses was built. In many of these houses new, previously unused, materials and constructions where introduced. Especially in the single family houses constructions as the concrete slab on the ground with heat insulation on top of the slab, cellars insulated on the inside, and the crawl space foundation were common. In many cases these constructions were the reason of moisture and mould problems. With the goal to solve indoor health problems the Swedish government started a fund to finance the improvement of single family houses with moisture damages. The fund was wound up in 2007.

The slab on the ground and the cellar constructions were improved in new houses during the 1980s.

Moisture damages in ground constructions are displayed in Table 3. In most houses the foundation is made out of one type of construction, but in some houses two or three different types of constructions were used, for example cellar combined with a crawl space.

Table 3: Mould and moisture problems in ground constructions.

Ground constructions in single family houses	Category of year	Number of ground constructions		Share <sup>1)</sup>
		(1000'th)		(%)
- cellars	- 75	150 ± 55		20 ± 7
	76-05	**		(6)
	total	155 ± 47		18 ± 5
-slab on the ground	-60			(3)
	61-75			15 ± 14
	76-85			7 ± 6
	86-05			0 ± 0
	total			8 ± 5
Crawl spaces	-75	153 ± 76		27 ± 13
	76-05	45 ± 20		24 ± 11
	total	197 ± 75		26 ± 9

( ), \*\* Uncertain value.

1)Share of damaged ground constructions in the same category.

The results in Table 3 shows that moisture damages are common in cellars up to the middle of the 1970s. In about 115 000 of these cellar the moisture damage is found in cellars with the heat insulation applied on the inside of the cellar walls or on top of the concrete slab. The rest of the moisture damages occurs from humid air and water suction through the cellar walls and floor.

### 5.3 New problem constructions

#### 5.3.1 The ETIC wall system

In the end of the 1980s a new facade construction for insulated wooden frame walls was introduced and it became very popular about ten years later. The facade system is made of facade plaster applied on a heat insulation on the outside of a gypsum board on the wooden framed wall. In most cases the facade plaster is quite thin and the wall is unventilated and undrained. The facade system is called the ETIC wall system.

Moisture damages are usually found on the gypsum board and the wooden parts. In many of these walls the ocular investigation was supplemented with an indicating measurement of the moisture content in the gypsum board. The measurement was made with an electrical equipment for measure moisture content in wood. A value between 15-19 percent of moisture content showed a risk of damage and a value above 19 percent showed damage. The credibility in these values had been tested. [6]

Table 4: The ETIC wall system with the amount of buildings with moisture damages and with the risk of a damage in the wall. The Table also show the amount of buildings with this type of wall without a damage together with not investigated buildings.

	Walls with no damages and not investigated walls		Walls with a risk of moisture damages		Walls with a moisture damage	
	Number (1000'th)	Share (%)	Number (1000'th)	Share (%)	Number (1000'th)	Share (%)
Single family houses	< 1	9	4	49	3	42
Apartment buildings	< 2	53	<1	25	<1	22
Single family houses and apartment buildings	2	20	5	43	4	37

The values are showed without any confidence intervals

### 5.3.2 The attic

In the Swedish building stock about 88 percent of the buildings have a roof construction with an attic and most of them where possible to inspect. In the other types of roofs the frame construction was hidden and only visible damages on the surfaces was able to inspect.

Previously the attic was not associated with moisture problems but nowadays there is an ongoing discussion about the risk of moisture problems in the connection with high heat insulation. The results of moisture damages are displayed in the Table 5.

Table 5: Attics with a moisture damage

Type of building	Attics with a moisture damage	
	Number (1000'th)	Share (%)
Single family houses	434 ± 125	23 ± 7
Apartment buildings	11 ± 5	7 ± 3
Commercial buildings	4 ± 2	8 ± 5
All buildings	449 ± 127	21 ± 6

Table 5 shows that moisture damages are very common, especially in single family houses. In about 15 percent of the attics there was mould or bad smell due to high relative humidity. The rest of the moisture damages occurred from rain leakage.

### 5.4 Moisture damages in buildings during time

The ELIB study showed the statistical extent of moisture damages 1991 in buildings that was built up to 1989. The BETSI study shows the statistical extent of moisture damages in buildings 17 years later. The results are displayed in figure 1,

The share of  
moisture damages

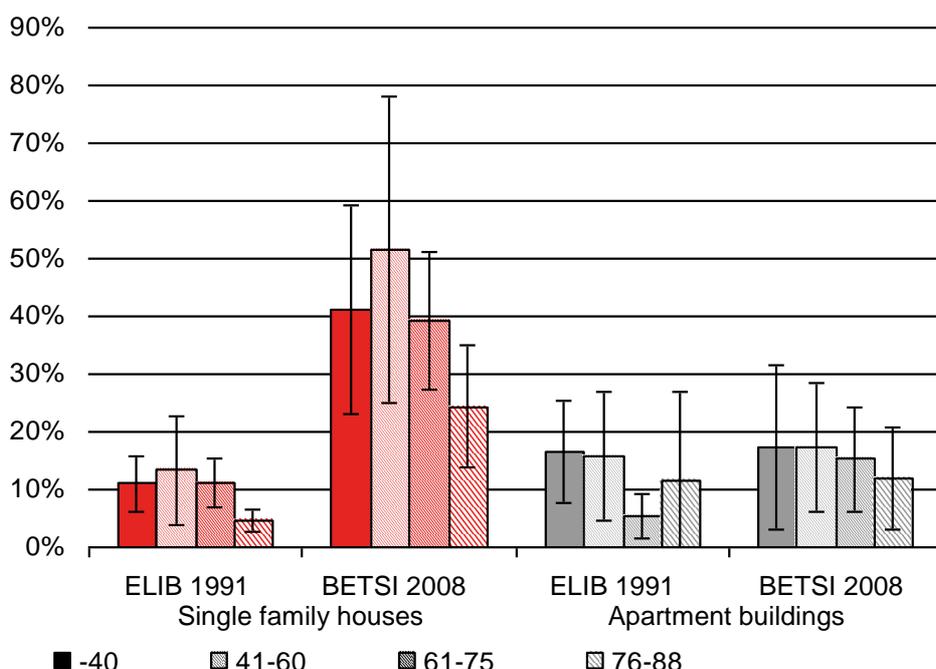


Figure 1 Comparison between moisture damages in single- and multifamily houses 1991-92 and 2007-08. Moisture damages in bathrooms are not included.

## 6. Discussion

The results of the BETSI study shows that there are about 751 000 Swedish buildings, mostly single family houses with moisture and mould damages that more or less can be harmful for the occupants health. Many of these damages depends on bad construction design both on older and new buildings. Although we have learned from earlier mistakes it seems that new products sometimes can be insufficient in design and testing. There are still many houses from the 1970s and older with moisture damages that have to be taking care of.

The attic and the crawl space foundation are constructions where mould growth seems to have increased during the last decades in older single family houses, but also in attics in new houses. The investigation have not given the answer why, but some hypothesis are the relatively warm winter climate during the 1990s up to 2006. For attics there also have been a development of the construction with increased heat insulation in new houses and additional heath insulation in existing houses. The knowledge about mould and moisture problems have increased during the last decades and the surveyors perhaps have more attention to mouldgrowth and bad odor nowadays.

The conclusion is that moisture damages can be a threat against sustainable buildings due to many older bad constructions still remains and new untested constructions are built, with the risk that some of them gradually can lead to moisture damages and health problems In today's houses.

## 7. References

- [1] BOVERKET, "Så mår våra hus - Redovisning av regeringsuppdrag beträffande byggnaders tekniska utformning m.m", The Swedish National Board of Housing, Building and Planning, Karlskrona, Sweden, 2009.
- [2] BOVERKET, ÅBERG O, THUNBORG J, "God bebyggd miljö – förslag till nytt delmål för fukt och mögel – Resultat om byggnaders fuktskador från projektet BETSI", The Swedish National Board of Housing, Building and Planning, Karlskrona, Sweden, 2011.
- [3] WHO, "Damp and mould Health risks, prevention and remedical actions", WHO Europe, Copenhagen, Denmark, 2009.
- [4] TOLSTOY N, "Method to describe the technical characteristics of the existing buildings - A Swedish survey of 1800 buildings" Sustainable Buildings 2011.
- [5] TOLSTOY N, BORGSTRÖM M, HÖGBERG H, NILSON J "Bostadsbeståndets tekniska egenskaper - ELIB rapport nr 6" Forskningsrapport TN 29, SIB, Gävle, Sweden, 1993.
- [6] SAMUELSON I, JANZON A, "Putsade träregelväggar" SP rapport 2009:16, SP Technical Research Institute of Sweden, Borås, Sweden 2009.